

**U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
OFFICE OF QUALITY ASSURANCE**

AUDIT REPORT

OF

**UNITED STATES GEOLOGICAL SURVEY
AT
DENVER, COLORADO
DECEMBER 1 THROUGH 4, 1997**

AND

**LOS ALAMOS NATIONAL LABORATORY
AT
LOS ALAMOS, NEW MEXICO
DECEMBER 8 THROUGH 10, 1997**

REPORT USGS/LANL-ARP-98-03

**Prepared by: _____
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Office of Quality Assurance**

Date: _____

**Approved by: _____
Donald G. Horton
Director
Office of Quality Assurance**

Date: _____

1.0 EXECUTIVE SUMMARY

As a result of Performance Based Quality Assurance (QA) Audit USGS/LANL-ARP-98-03, the audit team determined that United States Geological Survey (USGS) is satisfactorily implementing the QA Program and effective process controls for two synthesis reports. The first was developed under Work Breakdown Structure (WBS) 1.2.3.3.1.1.4, “Regional Hydrologic System Syntheses and Modeling, Milestone SP23OM3, Regional Saturated–Zone Synthesis Report,” and the second was developed under WBS 1.2.3.3.1.3.3 “Saturated-Zone Hydrologic Syntheses and Modeling, Milestone SP23NM3 Site Saturated–Zone Synthesis Report.”

In addition to the above, the Los Alamos National Laboratory (LANL) has developed a third synthesis report described under WBS 1.2.3.4.1.5.1, “Retardation Sensitivity Analysis, Milestone SP25CM3A Saturated-Zone Radionuclide Transport Model.” The audit team determined that the Civilian Radioactive Waste Management System Management and Operating Contractor (CRWMS M&O) at LANL did not effectively implement the QA Program and process controls. This resulted in the issuance of two Deficiency Reports (DR). The first DR LANL-98-D-021 identifies a violation of the Quality Assurance Requirements and Description Document (QARD), and delineates procedural inadequacies relative to the authority, responsibilities, and processes associated with the Configuration Control Board software approval methods. The second DR LANL-98-D-022 identifies a violation of the QARD, in that LANL failed to perform Scientific Investigations using Scientific Notebooks (SN), implementing documents, or a combination thereof.

As a result of the technical review associated with the three deliverables, it was determined that, although the milestones met the evaluation criteria extracted from the “Project Planning Sheets” (PPS), they did not provide the expected results. This adverse condition was attributed to a lack of programmatic controls in planning and communication of “expected results,” and in-processes technical over-site to assure usability of the end products was being achieved. See Section 5.4, “Technical Audit Activities” for details. This deficiency is documented as DR LVMO-98-D-027.

The audit team determined, with the exception of the deficiencies noted, that USGS and LANL staff personnel involved in the reports were highly qualified and had competently performed the technical activities required to produce the reports. The technical specialists have provided five recommendations, which are detailed in Section 6.0, “Recommendations.”

2.0 SCOPE

The audit was conducted to evaluate the adequacy and effectiveness of USGS and LANL controls for the development of the three technical reports.

- U.S. Geological Survey – Yucca Mountain Project Branch 1997 Milestone Report SP23OM3, “Regional Saturated-Zone Synthesis Report.”
- U.S. Geological Survey – Yucca Mountain Project Branch 1997 Milestone Report SP23NM3, “Site Saturated-Zone Synthesis Report.”
- Los Alamos National Laboratory – Milestone SP25CM3A, “Saturated Zone Radionuclide Transport Model.”

The audit was intended to establish confidence in the reports by determining the level of compliance with QA Program requirements and technical criteria described in the Participant Planning Sheets for WBS 1.2.3.3.1.1.4, WBS 1.2.3.3.1.3.3, and WBS 1.2.3.4.1.5.1. The audit team conducted interviews and documentation reviews in accordance with the approved audit plan to evaluate the processes and activities used to produce the reports

PROCESS/ ACTIVITY/ END-PRODUCT

The following deliverables were evaluated during the audit:

- WBS 1.2.3.3.1.1.4, U.S. Geological Survey - Yucca Mountain Project Branch 1997 Milestone Report SP23OM3, “Regional Saturated-Zone Synthesis Report.”
- WBS 1.2.3.3.1.3.3, U.S. Geological Survey - Yucca Mountain Project Branch 1997 Milestone Report SP23NM3, “Site Saturated-Zone Synthesis Report.”
- WBS 1.2.3.4.1.5.1, Los Alamos National Laboratory - Milestone SP25CM3A, “Saturated Zone Radionuclide Transport Model.”

The performance-based evaluation of performance effectiveness and product adequacy was based upon:

1. Satisfactory implementation of critical process steps.
2. Acceptable results and quality of the end product.
3. Documentation that substantiates the quality of the product.
4. Performance of trained and qualified personnel.
5. Implementation of applicable QA Program elements.

The activities for preparing the three Milestone Reports were evaluated for the critical process steps identified below:

1. Data source and control.
2. Data analyzed with appropriate reviews and entered into the database and checked for accuracy.
3. Software control.
4. Numerical model.
5. Model codes
6. Flow model calibrations.

7. Model output reporting.
8. Independent reviews and resolution of comments.
9. Qualification of reviewers.
10. Control of data update and changes.
11. Genesis input.

TECHNICAL AREAS

The audit included a technical evaluation of the development, application of critical processes, and adequacy of the three reports. Details of the technical evaluation are delineated in Section 5.4.

3.0 AUDIT TEAM AND OBSERVERS

Name/Title/Organization

Donald J. Harris, Audit Team Leader, Office of Quality Assurance (OQA).
Lawrence W. McGrath, Audit Team Leader in Training, OQA.
James Blaylock, Auditor, OQA.
Michael A. Goyda, Auditor, OQA. (LANL only)
Keith M. Kersch, Technical Specialist, CRWMS M&O.
Floyd H. Dove, Technical Specialist, Management and Technical Support (MTS).
Susan Zimmerman, Observer, State of Nevada.

4.0 AUDIT MEETINGS AND PERSONNEL CONTACTED

The audit was conducted at two locations, USGS, Denver CO., and LANL, Los Alamos, NM.

A pre-audit meeting was conducted at USGS on December 1, 1997, and LANL on December 8, 1997. Daily briefings were conducted to appraise the management and staff of the audit progress at each location. A post-audit meeting was conducted at USGS on December 4, 1997, and at LANL on December 10, 1997.

Personnel contacted during the audit are listed in Attachment 1, including those who attended pre-audit and post-audit meetings.

5.0 SUMMARY OF AUDIT RESULTS

5.1 Program Effectiveness

The audit team concluded that the process controls and activities implemented at USGS for WBS 1.2.3.3.1.1.4, and WBS 1.2.3.3.1.3.3 were being effectively implemented.

The audit team concluded that, the process controls and activities implemented at LANL for WBS 1.2.3.4.1.5.1 were not effective. See the “**Summary of Deficiencies**,” Section 5.5, of this report.

5.2 Stop work or Immediate Corrective Actions Taken

There were no stop work orders, immediate corrective actions, or related additional items resulting from this audit.

5.3 QA Program Activities

A summary table of the audit results is provided in Attachment 2. The details of the audit evaluation, with the objective evidence reviewed, are contained within the audit checklist. The checklist is maintained as a QA record.

5.4 Technical Audit Activities

The following deliverables were reviewed during the audit:

- 1) U.S. Geological Survey - Yucca Mountain Project Branch 1997 Milestone Report SP23OM3, “Regional Saturated-Zone Synthesis Report.”
- 2) U.S. Geological Survey - Yucca Mountain Project Branch 1997 Milestone Report SP23NM3, “Site Saturated-Zone Synthesis Report.”
- 3) Los Alamos National Laboratory - Milestone SP25CM3A, “Saturated Zone Radionuclide Transport Model.”

Deliverables 1 and 2 were examined at USGS in Denver, Colorado, and discussions with Frank D’Agnese, Claudia Faunt, and John Czarnecki were also conducted. All three of these investigators are competent, qualified researchers. They are effective in their work and have a good understanding of the quality assurance requirements of the project. The USGS documentation of the model development process as implemented in the extensive SN maintained by John Czarnecki was impressive. However, there is a need to provide “complete” references when cited in technical reports for future retrieval by the public. The authors cited several references where the source of information would not be retrievable to future reviewers of the report as a result of this condition. Several references to personal communications and written communications were also noted, which should be avoided in the future, reference Recommendation 2.

The site-scale model, documented in deliverable 2, was not well matched to fluxes in corresponding zones of the regional groundwater flow model, particularly north of the potential repository block. Also, the grid spacing was based on a regional perspective of 1500 meters. This distance was considered to be too coarse for radionuclide transport simulations by the LANL. Work is continuing on the site-scale model of groundwater flow in the saturated-zone to reduce the grid spacing as low as 250 meters. There is a trade-off in this process between resolution for transport simulations and the computer time needed to arrive at a simulation of the groundwater flow field. The milestone met the work-scope criteria for evaluating the final product, but a groundwater flow model for use at the site scale was not achieved, particularly at distances less than 5,000 meters from Yucca Mountain.

Deliverable number 3 was examined at LANL in Los Alamos, New Mexico. George Zyvoloski and Bruce Robinson were interviewed during the audit. The product that they produced appeared to be creative within the constraints that were imposed on them; however, they could not use the USGS site-scale flow model for their transport calculations and substituted a Sandia National Laboratories (SNL) groundwater flow model instead. This substitution exposed the fact that a useable site-scale flow model, consistent with the regional groundwater model, was not available to the project for radionuclide transport calculations in the saturated-zone. There appeared to be a lack of process control and documentation of the model development process that led to this deliverable, reference Recommendation 2 and DR LANL-98-D-022. Yet, the deliverable satisfied the evaluation criteria as described in the Participant Planning Sheets (PPS) sheets.

Verification and validation documentation for the Finite Element Heat and Mass (FEHM) code LANL developed and used in Deliverables 2 and 3 was examined. It was noted that additional software was used in conjunction with the FEHM code and identified as GEOMESH/X3D, reference Recommendation 4. The development plan was good and contained numerous test problem solutions. At least one of the test problems needs to be reexamined, and the application of regression analysis to test problem results may show the model accuracy's to be less than those claimed in the code documentation. A rigorous peer review of the FEHM code would appear to be appropriate, see Recommendation 5.

5.5 Summary of Deficiencies

The audit team identified three deficiencies during the audit, for which three DRs have been issued.

5.5.1 Corrective Action Requests

None

5.5.2 Deficiency Reports

LANL-98-D-021

LANL procedures YM-QP-03.20 and YMP-QP-03.21 include provisions for a “Configuration Control Board (CCB)” (Software); however, the procedures do not describe: 1) Responsibilities and organizational interfaces of the CCB to the Affected Organizations; 2) Sequential description of the work activities performed by the CCB; 3) The selection and qualification of the CCB Chairman, Review Leaders and Reviewers; 4) Completion of software reviews by assigned reviewers and CCB review actions; and 5) Provisions for recording the results of the CCB reviews and acceptance.

LANL-98-D-022

The Saturated Zone Radionuclide Transport Model, Milestone SP25CM3A, was developed without SNs or implementing documents describing process, controls or required documentation.

LVMO-98-D-027

USGS and LANL currently use PPS and decontrolled Department of Energy (DOE) Study Plans as their planning documentation. The PPS do not satisfy the required information in the QARD, Paragraph 2.2.5, and the Study Plans are four to ten years old and do not reflect today’s program or requirements.

5.5.3 Performance Reports (PR)

None

5.5.4 Deficiencies Corrected During the Audit

None

5.5.5 Follow-up of Previously Identified Deficiency Documents

None

6.0 RECOMMENDATIONS

1. There is a need for a project level process to embrace the use of non-qualified data. The perception is that non-qualified data means that the product is inferior. There are many examples of products that are produced with good but unqualified data. In Milestone Report SP23NM3, "Site Saturated Zone Synthesis Report," the authors attempt to rate the validity of the non-qualified data used in construction of the model (see Table 1 in that report). Much of the data that is needed for input to Performance Assessment and design analyses was not obtained under a QA Program but is never-the-less valuable. Examples include data from farms, tornado sightings, and USGS topographic maps. This data should be judged for its applicability for a particular analysis. If it is deemed "suitable," the results should be graded as "qualified."
2. It is recommended that USGS improve the way that unpublished references are cited and used in project documents. All sources of information should be explicitly cited or included with the report. It is important that future readers of the report have access to the same information that the writers had. These references are in compliance with USGS policy as contained in Hansen, 1991 (*1). According to Yucca Mountain Project guidance, however, undocumented references are not acceptable because independent reviewers cannot verify them. Examples of improper references in Milestone Report SP230M3, "Regional Saturated-Zone Synthesis Report," include the following:
 - (a) At the bottom of page 14, R.M. Forester and others (USGS Survey, written communication, 1997). This same citation appears on Figure 2.
 - (b) At the top of page 15, R.M. Forester and Platt Bradbury (USGS, written communication, 1997). Is this the same as the previous citation?
 - (c) Six lines from the bottom of page 12 (DOE, written communication, 1993).
 - (d) Four lines from the bottom of page 29, (A.L. Flint and J.A. Hevesi, USGS, written communication, 1996). Is this the same as the citation in Table B identified with DTN GS96010832111.001?

DOE has accepted this milestone. As a result, changes to these types of references will be required in the deliverable. We have provided informal recommendations on how this can be acceptably accomplished through the Records Processing Center.

3. LANL should document the model development process (application of the Finite Element Heat and Mass (FEHM) Code as a detailed process model of the saturated-zone) through the use of SNs, reference DR LANL-98-D-022.
4. The GEOMESH/X3D code should be controlled under the LANL software Configuration Management System.
5. There are two recommendations associated with the FEHM code:
 - (a) The first one is that the authors reexamine the validation example related to pressure transient testing. The reported discrepancy between the model result and the Theis solution is much worse than cited in the report. The comparison should have been based on the changes in pressure calculated using the two methods rather than based on pressure values. The use of regression analysis on the model results should demonstrate the differences in solutions. The example was based on a simulated wellbore radius of less than an inch, which is unrealistic. This calculation is a transient flow solution and probably has no impact on the results of this milestone, because it uses a steady-state solution.
 - (b) It is recommended that the FEHM code be subjected to a rigorous peer review. This review should examine a range of input values to see how well the code handles nominal and extreme input conditions. Most of the important features in the code should be examined. Even though the problem setup in the preceding validation example was an inappropriate test, there is a concern that the program may not simulate transient flow adequately. The peer review should assess the adequacy of the transient flow solutions.

References:

- (*1) Hansen, Wallace R., 1991, Suggestions to Authors of the Reports of the United States Geological Survey, Seventh Edition, U.S. Government Printing Office.

7.0 LIST OF ATTACHMENTS

Attachment 1: Personnel Contacted During the Audit
Attachment 2: Summary Table of Audit Results

ATTACHMENT 1
USGS
PERSONNEL CONTACTED DURING THE AUDIT

<u>Name</u>	<u>Organization/Title</u>	<u>Preaudit Meeting</u>	<u>Contacted During Audit</u>	<u>Postaudit Meeting</u>
Chaney, T.	USGS/Engineering Assurance Chief	X		X
Chornack, M.	USGS-Water Resources Division/Chief HMT			X
Corbett, C.	USGS/Software Control		X	
Czarnecki, C.	USGS/Principal Investigator		X	
D'Agnese, F.	USGS/Hydrologist	X	X	
Ducet, G.	USGS/Associate BR Chief	X		X
Faunt, C.	USGS/Hydrologist/Principal Investigator	X	X	
Lewis, K.	USGS/QA Specialist	X		X
McKinley, P.	USGS/Hydrologist	X	X	
Mustard, M.	USGS/Engineering Assurance Hydrologist	X	X	X
Nelson, M.	USGS-Training/Training Coordinator		X	
Parks, B.	USGS/Associate Chief, ESIP	X	X	X
Sheaffer, P.	USGS-PWT/QA Implement Specialist		X	X
Sinks, D.	OQA-QATSS-SAIC/QA Specialist	X	X	X
Tucci, P.	USGS/Hydrologist	X	X	X
Whiteside, A.	QATSS-SAIC/ OQA On-Site Representative	X		X

Legend:

BR	Branch
ESIP	Earth Science Investigation Program
HMT	Hydrological Model Team
OQA	Office of Quality Assurance
PWT	Pacific Western Technologies
QA	Quality Assurance
QATSS	Quality Assurance Technical Support Services
SAIC	Science Applications International Corporation
USGS	United States Geological Survey
YMP	Yucca Mountain Site Characterization Project

ATTACHMENT 1
LANL
PERSONNEL CONTACTED DURING THE AUDIT

<u>Name</u>	<u>Organization/Title</u>	<u>Preaudit Meeting</u>	<u>Contacted During Audit</u>	<u>Postaudit Meeting</u>
Clevenger, M.	LANL-TAPL			X
Hirons, T.	LANL-YMP/Lab Lead	X		
Ickes, T.	LANL-LATA/SCM		X	X
Martinez, C.	LANL-LATA/TAL	X	X	X
Robinson, B.	LANL/Principal Investigator		X	
Souza, L.	OQA-QATSS/Site Representative	X	X	X
Warren, C.	OQA-QATSS/Internal Audit Lead			X
Young, J.	LANL-LATA/TAL	X	X	X
Zimmerman, S.	State of Nevada/Observer	X		
Zyvoloski, G.	LANL/Staff Member	X	X	

Legend:

LANL	Los Alamos National Laboratory
LATA	Los Alamos Technical Associates
OQA	Office of Quality Assurance
QATSS	Quality Assurance Technical Support Services
SCM	Software Configuration Management
TAL	Technical Assurance Liaison
TAPL	Technical Assurance Project Leader
YMP	Yucca Mountain Site Characterization Project

ATTACHMENT 2
USGS
Summary Table of Audit Results
For Procedural Compliance Evaluations

Element	Implementing Documents	Details (Checklist)	Deficiencies	Recommendations	Program Adequacy	Procedure Compliance	Overall
2.0	YMP-USGS-QMP-2.02, R6, YMP-USGS-QMP-3.03, R7, YMP-USGS-QMP-3.04, R9, YMP-USGS-QMP-5.05, R4	pgs. 2-19			SAT	SAT	SAT
5.0	YMP-USGS-QMP-3.03, R7, YMP-USGS-QMP-3.04, R9, YMP-USGS-QMP-5.01, R6	pgs. 21-24			SAT	SAT	
6.0	YMP-USGS-QMP-6.01, R6, YMP-USGS-QMP-3.03, R7	pgs. 25-26			SAT	SAT	
15.0	AP-16.1Q, R. 1	pg. 27			SAT	SAT	
16.0	AP-16.2Q, R 2	pg. 28			SAT	SAT	
17.0	AP-17.1Q, R 0	pgs. 29-32			SAT	SAT	
SIII	YMP-USGS-QMP-5.05, R4-M3	pgs. 33-41			SAT	SAT	

ATTACHMENT 2
LANL
Summary Table of Audit Results
For Procedural Compliance Evaluations

Element	Implementing Documents	Details (Checklist)	Deficiencies	Recommendations	Program Adequacy	Procedure Compliance	Overall
2.0	LANL-YMP-QP-02.7, R4, LANL-YMP-QP-02.11, R 6	pgs. 1-4			SAT	SAT	SAT
5.0	LANL-YMP-QP-06.1, R8	pg. 5-9			SAT	SAT	
6.0	LANL-YMP-QP-06.2, R7	pgs. 10-11			SAT	SAT	
15.0	AP-16.1Q, R2	pg. 12			SAT	SAT	
16.0	AP-16.2Q, R 2	pgs. 13-14			SAT	SAT	
17.0	AP-17.1Q, R 0	pgs. 15-17			SAT	SAT	
SI	LANL-YMP-QP-03.21, R 7, LANL-YMP-QP-03.20, R 5	pgs. 26a- 26bb	LANL-98-D-021		SAT	UNSAT	
SIII	None	pgs. 18-26	LANL-98-D-022		UNSAT	UNSAT	

ATTACHMENT 2
USGS
Yucca Mountain Project Branch 1997 Milestone Report
SP230M3, “Regional Saturated-Zone Synthesis Report”

Activity	Process Steps	Details (Checklist)	Deficiencies	Recommendations	Process Effectiveness	Product Adequacy	Overall
Regional Saturated-Zone Synthesis Report	Data Source Control	pg. 3			SAT	SAT	SAT
	Data Reviews	pgs. 6, 8, 26			SAT	SAT	
	Software Control	pgs. 14-19			SAT	SAT	
	Numerical Model	(T) 1-25			SAT	SAT	
	Model Codes	(T) 18-20			SAT	SAT	
	Flow Model Calibrations	(T) 21-24			SAT	SAT	
	Model Reporting	(T) 1-25			SAT	SAT	
	Reviews and Comment Resolution	pg. 7			SAT	SAT	
	Qualification of Reviewers	pgs. 4-6			SAT	SAT	
	Control of Data Update and Changes	pgs. 14, 15, 20-24 & 26		1, 2	SAT	SAT	
	Genesis Input	pg. 9			SAT	SAT	

Table below includes “Critical Process Steps” that were evaluated during the audit that were not included in the Audit Plan.

Regional Saturated-Zone Synthesis Report	Scientific Investigation Planning	(T) 30-31	LVMO-98-D-027		SAT	UNSAT	SAT
	Control of Scientific Investigations	Pgs. 6-7 & 33-41			SAT	SAT	

ATTACHMENT 2
USGS
Yucca Mountain Project Branch 1997 Milestone Report
SP23NM3, “Site Saturated-Zone Synthesis Report”

Activity	Process Steps	Details (Checklist)	Deficiencies	Recommendations	Process Effectiveness	Product Adequacy	Ovrall
Site Saturated-Zone Synthesis Report	Data Source Control	pg. 3			SAT	SAT	SAT
	Data Reviews	pgs. 6, 8, 26			SAT	SAT	
	Software Control	pgs. 14-19			SAT	SAT	
	Numerical Model	(T) 30-31			SAT	SAT	
	Model Codes	(T) 48-51			SAT	SAT	
	Flow Model Calibrations	(T) 32-39, 41-47			SAT	SAT	
	Model Reporting	pgs. 52-56			SAT	SAT	
	Reviews and Comment Resolution	pg. 7			SAT	SAT	
	Qualification of Reviewers	pgs. 4, 5, 6			SAT	SAT	
	Control of Data Update and Changes	pgs. 14, 15, 20-24, 26 (T) 33, 40		1, 2	SAT	SAT	
	Genesis Input	pg. 9			SAT	SAT	

Table below includes “Critical Process Steps” that were evaluated during the audit that were not included in the Audit Plan.

Site Saturated-Zone Synthesis Report	Scientific Investigation Planning	(T) 30-31	LVMO-98-D-027		SAT	UNSAT	SAT
	Control of Scientific Investigations	Pgs. 6-7 & 33-41			SAT	SAT	

ATTACHMENT 2
LANL
Milestone SP25CM3A,
“Saturated Zone Radionuclide Transport Model”

Activity	Process Steps	Details (Checklist)	Deficiencies	Recommendations	Process Effectiveness	Product Adequacy	Overall
Saturated-Zone Radio-nuclide Transport Model	Data Source Control	pgs. 18-26			SAT	SAT	SAT
	Data Reviews	pgs. 18-26			SAT	SAT	
	Software Control	pgs. 26a-26bb	LANL-98-D-021		UNSAT	SAT	
	Numerical Model	(T) 56, 61, 64			SAT	SAT	
	Model Codes	(T) 62-63, 72-77		3,4,5	SAT	SAT	
	Flow Model Calibrations	(T) 66-69			SAT	SAT	
	Model Reporting	(T) 78-79, (T) 80-95			SAT	SAT	
	Reviews and Comment Resolution	pg. 7			SAT	SAT	
	Qualification of Reviewers	pgs. 18-26			SAT	SAT	
	Control of Data Update and Changes	pgs. 18-26		1	SAT	SAT	
	Genesis Input	pgs. 15-17			SAT	SAT	

Table below includes “Critical Process Steps” that were evaluated during the audit that were not included in the Audit Plan.

Saturated-Zone Radio-nuclide Transport Model	Scientific Investigation Planning	Pgs. 1-4 (T)56,61,64 (T) 66-69 (T) 78-95	LVMO-98-D-027		UNSAT	UNSAT	UNSAT
	Control of Scientific Investigations	Pgs. 18-26	LANL-98-D-022		UNSAT	UNSAT	